42-1060-
Instruction manual

MODEL TP150/151 TEMPERATURE PROBE

DATA PRECISION

...years ahead

MP MASTER
MA28760

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Printed in U.S.A.
August 1978

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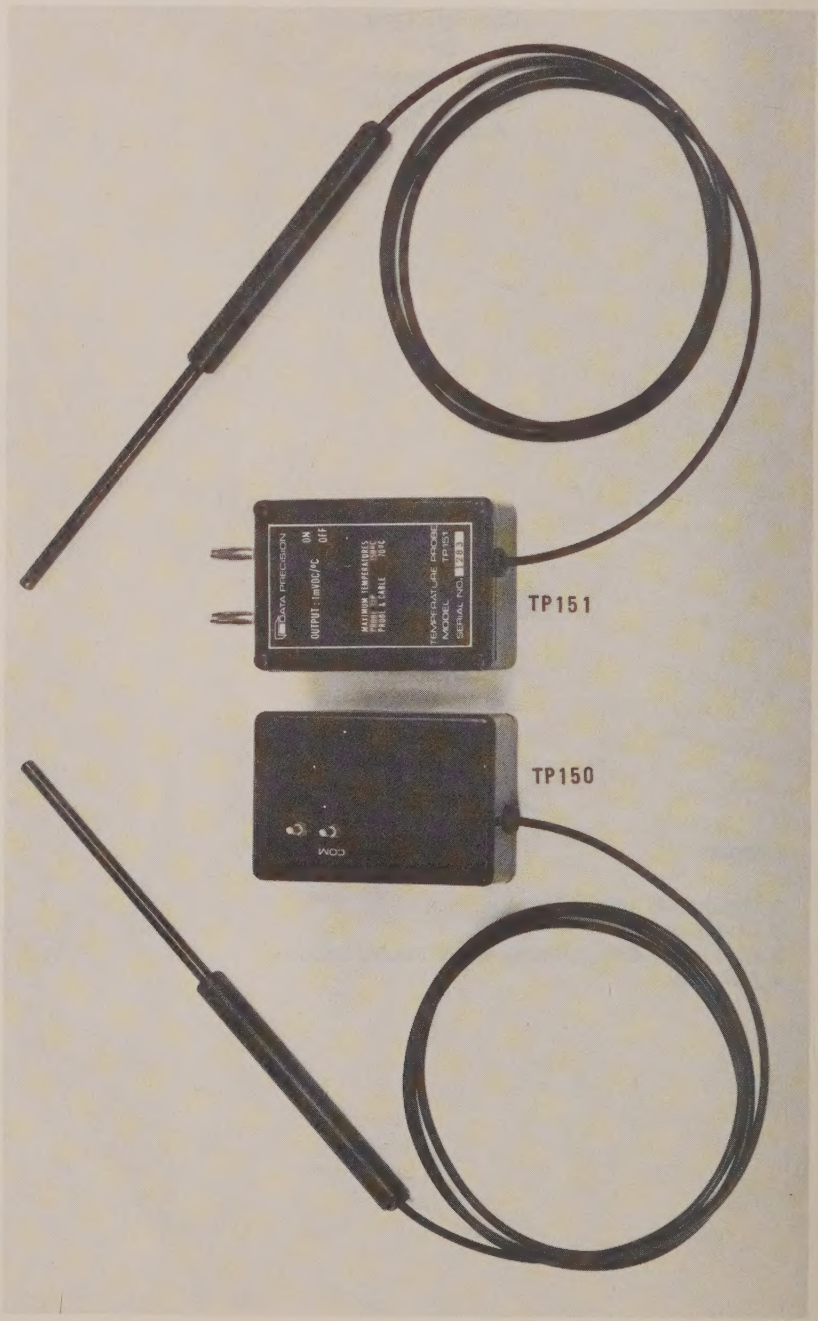
DATA PRECISION
OUTPUT : 1mV/DC
ON
OFF
TEMPERATURE PROBE
MODEL TP151
SERIAL NO.
TP151
COM
TP150

Chapter 1
DESCRIPTION & SPECIFICATIONS

1.1 INTRODUCTION

The Data Precision TP-150/151 is an accurate, convenient transducer which can be used with any voltmeter* to measure temperatures in the range −65°C to +150°C. The output of the temperature probe is 1 mVDC/°C. If used with a 100 mV scale the temperature is displayed directly in °C. Accuracy is ±1°C over the range −10°C to +110°C, with wider limits to −65°C and to +150°C. The probe is powered by a standard 9 volt battery which should provide power for 200 hours of operation. The tip is insulated from the rest of circuitry and provides 350 volts peak standoff isolation.

*Input resistance equal to or greater than 1 Megohm.

1.2 SPECIFICATIONS

Output

1 mV DC/°C

Range

−65°C to +150°C (−85°F to +302°F). The probe will indicate approximate temperatures outside this range, but loss of calibration and/or permanent damage to the sensor probe may result. The temperature of the sensor probe handle and cable must be limited to 70°C.

Accuracy

Over the range −10°C to 110°C: ±1°C.
Outside this range the accuracy decreases linearly:
At −65°C the error is between +2°C and +4°C.
At +150°C the error is between 0 and +3°C.

For convenience, the accuracy may be regarded as decreasing linearly from ±1°C at −10°C to ±4°C at −65°C and from ±1°C at +110°C to ±3°C at +150°C. However, measurements may be made with greater accuracy by taking advantage of the fact that at the extremes of temperature the error is always in the positive direction.

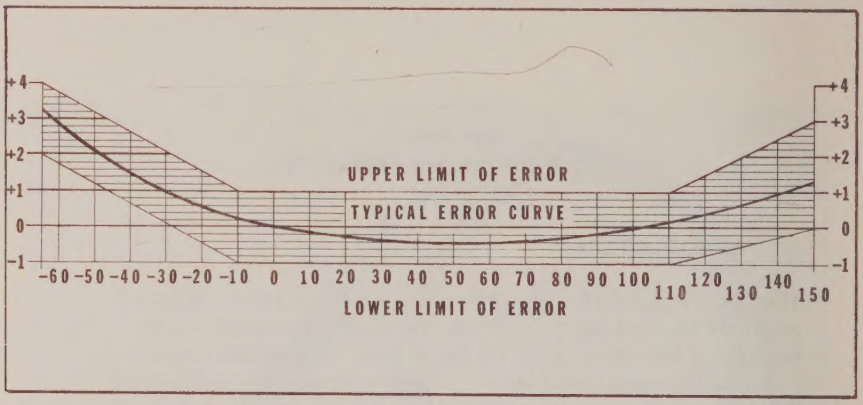

Figure 1-1. Error Boundaries

The ambient temperature sensitivity of the transducer circuitry is less than .03°C/°C. It is typically .01°C/°C. If the temperature probe is to be used outside the normal range of room temperatures, it may be recalibrated by the user at the temperature at which it will be used.

Source Impedance

Less than 1 kOhm; instrument is calibrated driving 10 Megohms.

Settling Time

Less than 8 seconds for a 100°C change to within 1°C of final reading.

Time Constant (63% response time)

In a well stirred water bath the time constant is approximately 1 second. In relatively still air the time constant is about 1 minute.

Standoff Isolation

350 volts peak between sensor probe tip and all parts of the circuit.

Mechanical/Physical

The sensor probe is 7 in. (180 mm) long. It consists of an epoxy/glass barrel 3½ in. (90 mm) long and $^3/_{16}$ in. (4.8 mm) in diameter and a Noryl® handle 3½ in. (90 mm) long and ⅜ in. (9.5 mm) in diameter. The aluminum tip of the sensor probe is .1" (2.5 mm) in diameter, and protrudes .1 in. (2.5 mm).

® Noryl is a GE trademark.

The cable is 48 in. (1.2 m) long.

The case measures 2.9 in. (73 mm) by 2 in. (50 mm) by 1 in. (25 mm) exclusive of the banana plugs.

Weight of the unit is 4 oz. (.12 kg), including battery.

Note: Remove the battery for long-term storage or shipment.

1.4 MODEL TP-150/TP-151 DIFFERENCES

The TP-150 and the TP-151 are identical except for the banana plugs. The TP-150 is equipped with miniature (⅜ in. center) plugs, while the TP-151 has standard (¾ in. center) plugs.

WARNING

The sensor probe tip is isolated electrically from the transducer circuitry ONLY FOR VOLTAGES *UP TO* 350 VOLTS PEAK. HIGHER VOLTAGES EXPOSE THE USER TO SERIOUS HAZARDS.

When measuring high temperatures, remember that the probe tip does not cool immediately and be sure not to touch it until it has cooled.

CAUTION

Be sure not to exceed the temperature range of the probe components. The sensor probe tip and barrel may be used over the range −65°C to +150°C. Approximate temperatures will be indicated outside this range, but loss of calibration and/or permanent damage may result. The handle and cable are limited to 70°C.

Avoid unnecessary thermal shock. Sudden temperature changes much greater than 100°C could damage the sensor probe.

Chapter 2
OPERATION

2.1 INSTALLING THE BATTERY

The temperature probe is shipped with the battery outside the case to avoid possible damage due to leakage. To install the battery, remove the 4 cover screws and attach the battery connector. Place the battery and its wires in the case so that the battery connector is at the same end of the case as the sensor probe cable. Take care not to disturb the settings of the calibration adjustments. Replace the cover and screws, being careful not to over-tighten.

2.2 MEASURING TEMPERATURES

Connect the temperature probe to a DC voltmeter (input resistance ≥ 1 Megohm). If the meter is set to a millivolt scale, the display will read directly in °C. On a scale reading in volts the decimal point should be shifted 3 places to the right.

Turn the probe on. Place the sensor probe tip in contact with the material the temperature of which is to be measured. Wait for the reading to stabilize and read the temperature.

Turn the probe off when it is not in use.

2.3 FOR GREATEST ACCURACY

These precautions help to assure the most accurate measurements:

a. Good thermal contact between the sensor probe tip and the material under test is especially important. If the barrel is immersed a few inches or so this is not a problem with gases, liquids, and powders. Care is required when measuring the temperature of solids. Thermal compound on the tip is helpful.

b. Consider the disturbing effect of the sensor probe on the system under test. The thermal mass of the probe tip is very small, but in a few cases it may be desirable to pre-heat or pre-cool the tip to a temperature near that of the material to be measured. The thermal conductivity of the probe barrel is slight, but in some instances it may be a good idea to insulate the barrel to reduce heat loss. This should only rarely be necessary.

c. Prior to making critical measurements, an ice bath may be used to check the 0°C reading. Possible errors due to ambient (room) temperature changes are thus minimized.

d. The "Typical Error Curve" (Figure 1-1) shown in the *Accuracy* section may be used to correct readings taken with the temperature probe. To do this, find the temperature reading on the horizontal axis. The "Typical Error Curve" then shows a correction factor on the vertical axis. Subtract this factor from the reading for the best estimate of the temperature.

Examples:

Temperature reading shown on voltmeter is 45.8°C. The "Typical Error Curve" at this temperature shows about −0.4°C. (45.8°C−(−0.4°C)) = 46.2°C. This is the best estimate.

Reading: 140.7°C. Typical error: +1.0°C. (140.7°C−1.0°C) = 139.7°C.

Reading: −57.2°C. Typical error: +2.6°C. −57.2°C −2.6°C = −59.8°C.

Chapter 3
CALIBRATION
CIRCUIT DESCRIPTION
AND TROUBLESHOOTING

3.1 INTRODUCTION

The TP-150/151 has two non-interactive calibration adjustments, the 100°C (gain) adjustment and the 0°C (offset) adjust. They require calibration annually.

The ice point of water is an extremely accurate temperature reference which may easily be prepared. To check the 0°C reading on receiving the instrument, or prior to making critical measurements, follow the procedure given in the following section.

For best accuracy the ambient temperature during calibration should be approximately equal to the ambient temperature during use. The ambient sensitivity is typically .01°C/°C.

3.2 SETTING THE 0°C ADJUSTMENT (Figure 3-1)

In order to reset the 0°C adjustment, place the probe tip in an ice bath. Wait 15 to 30 seconds for thermal equilibrium. Adjust R2 for zero output voltage. The proper setting of R6 (the 100°C adjustment) is not affected by this procedure.

0°C Reference Bath

An ice bath for calibration may be prepared using any drinking water; for best accuracy use distilled water and ice made from distilled water. The ice must be finely divided and completely covered with water, but there should not be an excess of water at the bottom of the bath. A good procedure is to put equal quantities of cracked ice and water in a blender and blend until the ice is finely ground. Put the ice and water in a suitable container (an insulated container is best) and pour off the excess water. Insert the probe, making sure it is surrounded by ice and does not touch the walls of the container. The temperature of the bath prepared in this manner is typicaly 0°C ± .02°C.

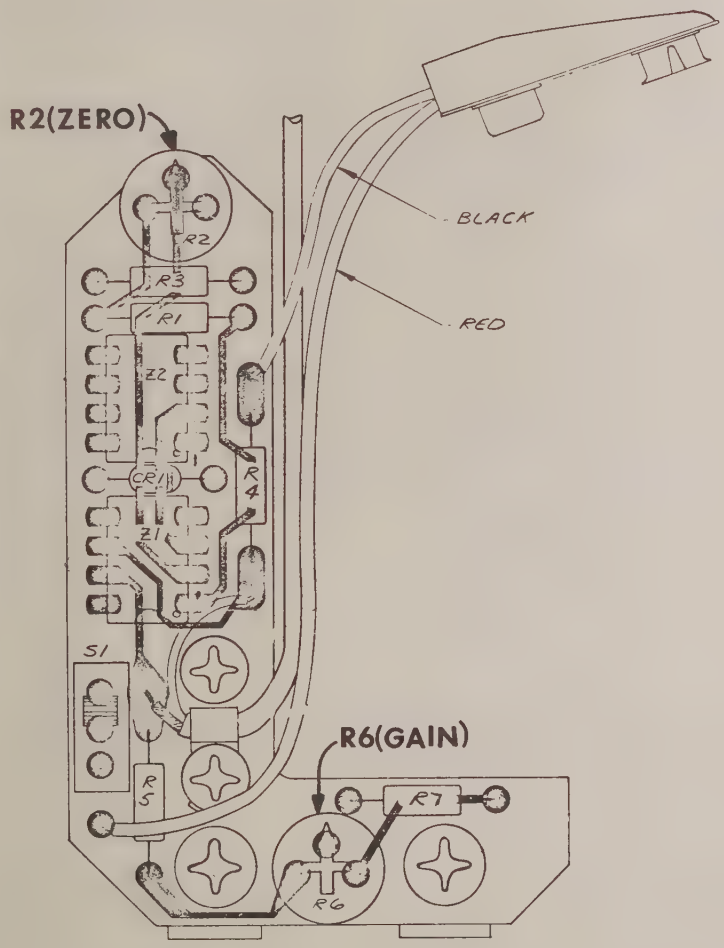

Figure 3-1. Assembly drawing showing location of ZERO and GAIN adjustments

3.3 SETTING THE 100 C (GAIN) ADJUSTMENT* (Figure 3-1)

The 0 C adjustment should be checked prior to resetting the 100°C adjustment. This order of calibration avoids interaction of the adjustments.

Place the probe in a bath between 95° C and 105°C. The temperature of the bath must be known to about 0.1°C. When the temperature of the probe tip has stabilized, adjust R6 to provide a millivolt output equal to the temperature in °C.

Recalibration at 100 C should rarely be required, because the gain factor depends only on dV_{BE}/dT and the ratio of resistors R5, R6, and R7.

The calibration procedures used at the factory and described here result in best accuracy in the – 10°C to 110 C range. The TP-150.151 may be recalibrated by the user for greater accuracy in other parts of the range.

*If a calibration temperature other than 0 C is used, there will be an interaction between the two adjustments, requiring iteration to reach the final settings.

100 C Reference Bath

An accurate 100 C reference bath is more difficult to obtain. For factory calibration, an NBS-traceable platinum resistance thermometer is used to monitor an oil bath. The condensation point of steam may be used as a temperature reference, if it is corrected for local barometric pressure*, but it is not easily achieved. The temperature of boiling water often varies substantially throughout the container.

*For barometric pressures between 660 mm Hg and 860 Hg the steam point is within .01°C of $[100 + 28\,(P/760\text{-}1) - 11.6\,(P/760\text{-}1)^2 + 7\,(P/760\text{-}1)^3]$°C.

3.4 CIRCUIT DESCRIPTION (Figure 3-2)

Q101, mounted in the sensor probe tip, is connected as a diode and driven with a constant current of 25 μA. In this configuration, V_{BE} decreases with increasing temperature at a rate of approximately 2.35 millivolts/°C.

Z2 provides a regulated 2.5 volt supply.

Z1B holds E3 at 2.5 volts, resulting in a constant 25 μA current out of the emitter of Q101. This holds E4 at 2.5 + V_{BE}.

With the sensor probe tip in an ice bath, the network composed of R1, R2, R3, and Z1A is adjusted to set the voltage at E6 equal to the voltage at E4.

R5, R6, and R7 form a 2.35 to 1 attenuator adjusted to provide an output of 1 millivolt/°C.

CR1 protects the circuit against damage caused by reverse connection of the battery.

Normal battery drain is about 1.5 mA.

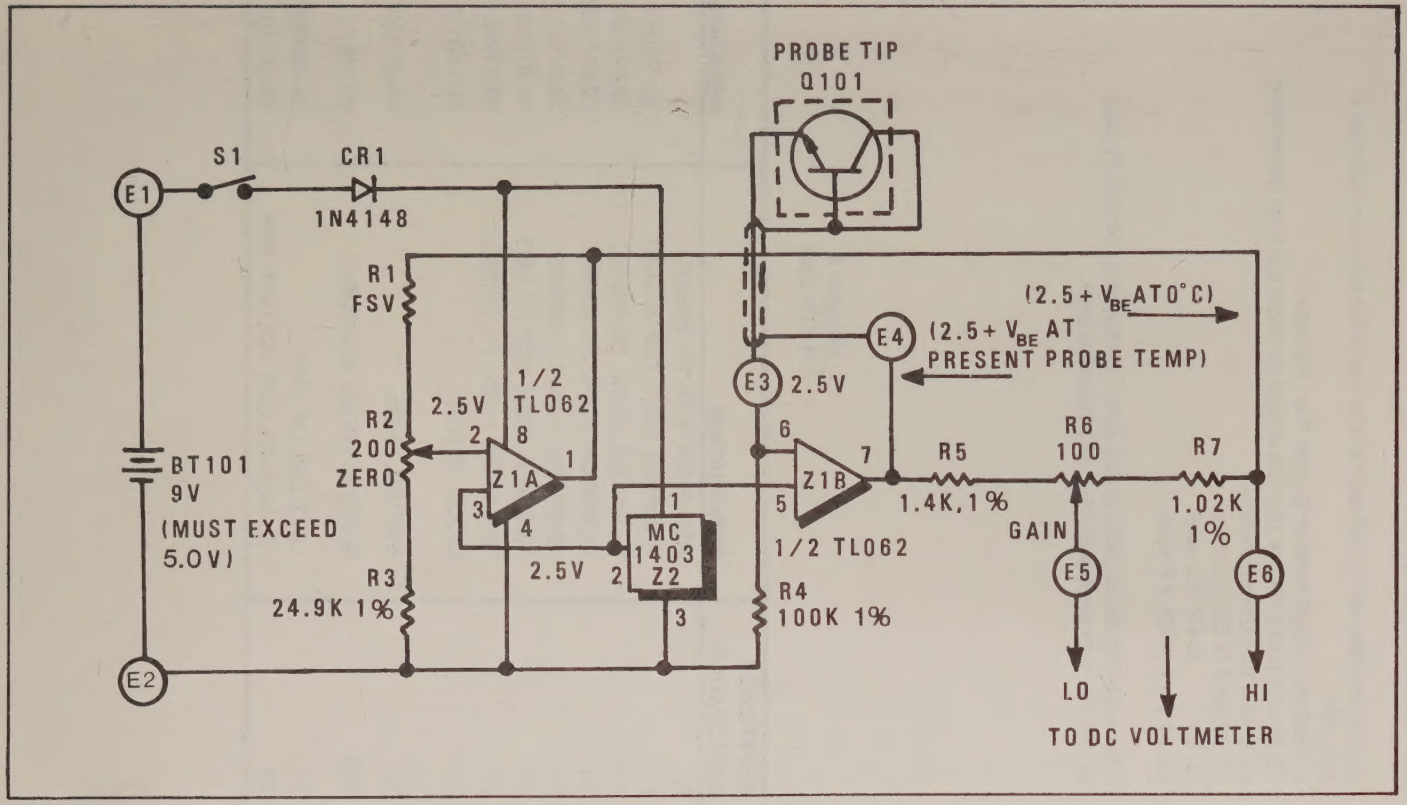

Figure 3-2. TP-150/TP-151 Schematic Diagram

3.5 TROUBLESHOOTING

A good troubleshooting procedure is to check the following voltages in this order:
(1) Battery voltage must be greater than 5.0 volts.
(2) Sensor probe voltage (E4-E3) should be about 0.6 volts (depending on sensor probe temperature).
(3) Z2 pin 2 to E2: 2.5 volts.
(4) E3 to E2: 2.5 volts.
(5) Z1 pin 2 to E2: 2.5 volts.

After soldering connections on the board (if required), be sure to clean off the flux with alcohol or other P.C. board cleaner.

Chapter 4
PARTS LIST

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER
R1	RESISTOR, FSV, 1%, RN55C	
R2	TRIMMER, 200Ω, TOP ADJUST	22-673201-A
R3	RESISTOR, 24.9K, 1%, RN55C	22-342492
R4	RESISTOR, 100K, 1%, RN55C	22-341003
R5	RESISTOR, 1.4K, 1%, RN55C	22-341401
R6	TRIMMER, 100Ω, TOP ADJUST	22-673101-A
R7	RESISTOR, 1.02K, 1%, RN55C	22-341021
CR1	DIODE, 1N4148	24-110001
S1	SWITCH, SLIDE	25-441008
SP1	SENSOR PROBE ASSEMBLY	40-1077
Z1	I.C. TL062, OP AMP	24-400062
Z2	I.C. MC1403, LOW VOLTAGE REF.	24-401403

42-1060

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